



ENERGY STAR® Manufacturer's Guide for Qualifying Solid State Lighting Luminaires – Version 2.0

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Table of Contents

Manufacturer Submission Checklist	2
Technical Interpretations by U.S. Department of Energy	4
Scope	8
Pre-qualification Activities	8
Submittal Process	11
On-line Product Submission Tool	11
Testing	13
Temperature Measurement Point (TMP)	13
TMP for the LED (TMP _{LED})	13
TMP for the Power Supply (TMP _{PS})	13
Required Test Reporting and Tolerance	13
Lumen Maintenance Testing	18
OPTION 1: Component Performance	18
IESNA LM-80-2008	18
In Situ Temperature Measurement Test (ISTMT)	18
Conditions for Use	19
Test Procedure	20
Guidance for Thermocouple Attachment	20
TMP Evaluation	21
Component Performance “Passing” Threshold	23
Submittal requirement	23
OPTION 2: Luminaire Performance	24
Luminaire Performance “Passing” Threshold	24
Submittal requirement	24
Power Supply Qualification	24
Power Supply “Passing” Threshold	24
Submittal requirement	25
Attachment A	26
Product Groups	26
LED Platform	26
Component Substitution	27
Additional Requirements	27

Manufacturer Submission Checklist

Prequalification Activities

1. Sign up as a Partner.
 - ☐ Read and understand the Program Requirements.
 - ☐ Read and understand the ENERGY STAR criteria for SSL Luminaires.
 - ☐ Fill out Partnership Agreement and send to ssl@drintl.com.
 - ☐ Read and understand the SSL Manufacturer's Guide.
2. Find approved laboratories to test your products.
 - ☐ Photometric Testing, LM-79 Testing – *Laboratory must hold NVLAP accreditation for the LM-79-08 test procedure or must be qualified, verified, and recognized through the U.S. Department of Energy (DOE)'s CALiPER program.*
 - ☐ In-Situ Temperature Measurement Test (ISTMT) – *Laboratory must be approved by OSHA as a Nationally Recognized Testing Lab (NRTL), must be qualified, verified, and recognized through DOE's CALiPER program, or must be recognized through UL's Data Acceptance Program.*
 - For hardwired products, ISTMT must be conducted with the luminaire installed in the appropriate application as defined by ANSI/UL 1598.
 - For corded products, use ANSI/UL 153.
 - ☐ Lumen Maintenance Testing, LM-80 Testing – *Provided by LED package, array, or module manufacturer.*
3. Create a "Product Group"
 - ☐ If you are submitting more than one version of a product, choose one model for testing that represents a group of products. It must represent other group members within allowable variations identified in **Table 1** and be consistent with additional product group guidance in **Attachment A**.
4. Submit 1 sample of the representative model for testing to each of the following:
 - ☐ DOE CALiPER qualified labs – test for luminaire efficacy, light output, zonal lumen density, color rendering index, correlated color temperature, color spatial uniformity (if available), and optionally, lumen maintenance and color maintenance. (See lumen maintenance test options in **Table 2**.)
 - ☐ OSHA approved NRTLs or Laboratory qualified, verified, and recognized through DOE's CALiPER program or Laboratory recognized through UL's Data Acceptance Program – conduct In Situ Temperature Measurement Testing.
 - ☐ Independent or manufacturer-based testing laboratory – test for output operating frequency, noise, electromagnetic and radio frequency interference, transient protection, and for outdoor products, minimum operation temperature.

Submission Process

1. Sign in to your My ENERGY STAR Account (MESA).
 - ☐ To obtain a username and password, you must sign up as a partner.
2. Launch the on-line product submission tool at <http://www.energystar.gov/sslpartners>.

3. Enter product information.
- Required Documentation to upload into on-line tool:
 - A. IESNA LM-79-08 Photometric (Goniophotometry) Test Report (Formatted to LM-63-03)
 - B. IESNA LM-79-08 Integrating Sphere Output Report
 - C. For Lumen Maintenance, use either:
 - Option 1 – Component Performance***
 - ☐ LED Package Manufacturer LM-80 Test Report with results showing relative light output over time
 - ☐ In situ temperature measurement test (ISTMT) showing measured TMP_{LED}
 - ☐ Diagram or photograph of the Temperature Measurement Points for the package, array or module
 - Option 2 – Luminaire Performance***
 - ☐ IESNA LM-79-08 Test Report at time = 0 and 6,000 hours respectively.
 - D. For Power Supply (the ISTMT typically includes these results)
 - ☐ In situ temperature measurement test showing measured TMP_{PS}
 - ☐ Diagram or photograph of the Temperature Measurement Point for the power source
 - E. Warranty
 - Documentation for self-certification
 - A. A written statement showing the manufacturer self-certifies the product/grouping for Color Spatial Uniformity, Color Maintenance, Output Operating Frequency, Noise, Electromagnetic and Radio Frequency Interference, Transient Protection, and for Outdoor Products, Minimum Operating Temperature.
 - B. A written statement indicating the forward drive current (in milliamps, mA) applied to the LEDs in the luminaire.

Technical Interpretations by U.S. Department of Energy (DOE)

The following technical interpretations provide additional clarification, information, and/or examples pertaining to requirements stated in the ENERGY STAR for SSL Luminaires criteria or in the ENERGY STAR Manufacturers Guide for Qualifying SSL Luminaires.

I. Recessed, surface, and pendant-mounted downlights - Aperture

A .25" tolerance is allowed for the aperture size. "Aperture" is defined as the maximum distance between the points inside the luminaire where light escapes the luminaire.

II. Product Groupings -- CCT

If a manufacturer offers the same luminaire with different correlated color temperatures (CCTs), ENERGY STAR will allow those products to be grouped together, so long as the LED package(s)/module(s)/array(s), drive current, electronics, and thermal management are otherwise identical. At a minimum, manufacturer must submit one set of LM-80, In-situ Temperature Measurement Test (ISTMT), and LM-79 test results applicable to the product version with the lowest CCT.

III. Lumen Maintenance -- Luminaires employing remote phosphors

The LED package, array, or module must contain all optics and electronics which significantly change the color and/or intensity of the light emitted from the luminaire. Luminaires incorporating remote phosphors, secondary phosphors, optics, and/or color or intensity correction electronics that are not contained within the LED package, array, or module must be tested under OPTION 2.

IV. Lumen Maintenance -- Successor LED packages/modules/arrays

LED package manufacturers continue to improve their products, incorporating various upgrades into revised and next-generation packages. Typically these are incremental improvements, rather than entirely new products. To avoid significant delays in qualifying luminaires using LED packages that are successors to those previously approved for lumen maintenance in DOE's ENERGY STAR SSL program, DOE allows for provisional ENERGY STAR approval based on the following conditions:

1) The luminaire manufacturer must submit at least 3000 hours of lumen maintenance (based on LM-80) data for the successor LED package(s) used, at the appropriate temperature and drive current for the luminaire, and assuming all other required provisions for ENERGY STAR qualification are met by the luminaire.

2) At least 6000 hours of lumen maintenance data for the successor LED package(s) must be provided to the DOE ENERGY STAR SSL program as soon as available.

3) If complete lumen maintenance data is not provided within 6 months of the provisional approval date, all qualified luminaires using the successor packages will face de-listing.

V. Lumen Maintenance -- Required sample size for LED modules and arrays

For LM-80 lumen maintenance testing of LED modules and arrays, a sample size of less than 25 units per temperature is allowed, subject to the following conditions:

- 1) No fewer than 10 complete modules or arrays must be tested according to LM-80.
- 2) Testing may be conducted by the LED module or array manufacturer and/or by a qualified testing laboratory recognized by DOE's CALiPER program or holding NVLAP accreditation for the LM-80-08 test procedure.

VI. Lumen Maintenance -- Acceptance of historical lumen maintenance data

The final version of LM-80 was published in September 2008 with several significant changes relative to prior drafts, including how the case temperature is maintained (via ambient temperature versus current modulation) and in the three LED case temperatures at which the packages are maintained (55°C, 85°C, and one other temperature selected by the manufacturer, compared to the earlier drafts that required 45°C, 65°C and 85°C).

DOE recognizes that all LED manufacturers may not have 6,000 hours worth of data for all three case temperatures prescribed in LM-80. DOE therefore will allow prior data collected to be used for compliance purposes until March 31, 2010, after which date new product submissions will be required to include test lumen maintenance data collected in compliance with LM-80.

VII. Off-state Power

For products designed for use in a system configuration, i.e., multiple luminaires operating on a single power supply, off-state power requirements will be expanded from 0.5 watts to 1.5 watts. The rationale is that for such “systems”, DOE anticipates that at least three luminaires would be connected to a single power supply.

VIII. Under-cabinet shelf-mounted task lighting – Asymmetrical distribution

Zonal Lumen Density Requirement -- luminaires with asymmetrical distribution must have at least 12.5% of total luminaire lumens in the 60°-90° zone (see **Figure 1**). There is a 3% tolerance in the backward zone.

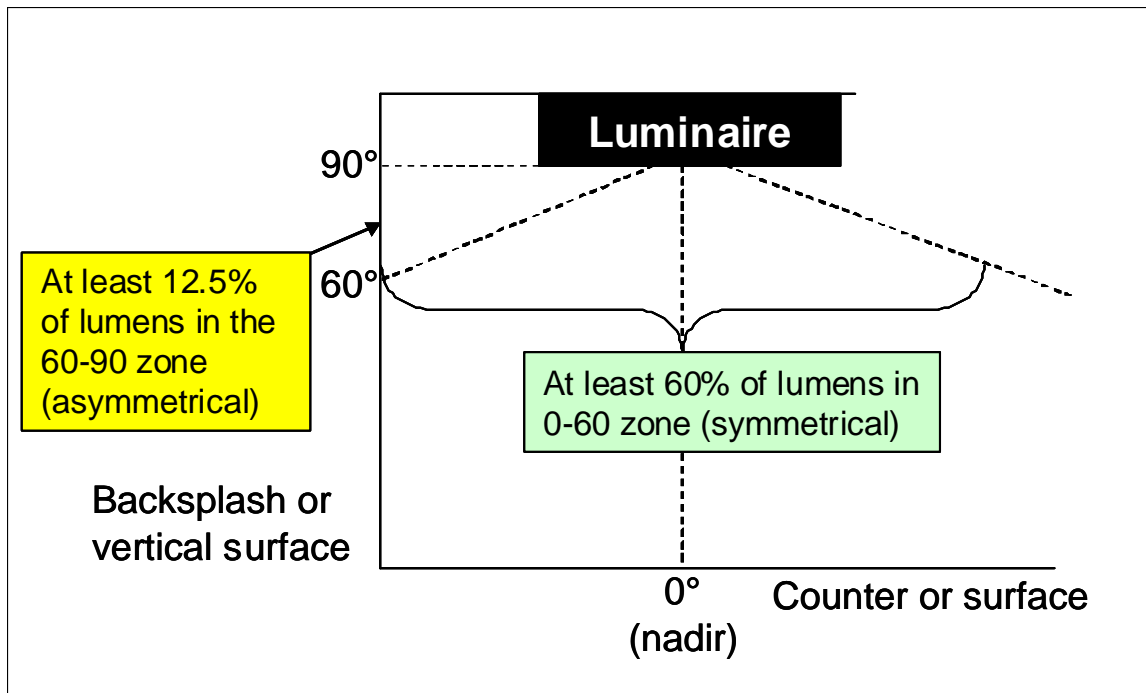


Figure 1 - Zonal lumen diagram for asymmetric under-cabinet products

IX. NVLAP Accreditation Requirement

As originally stated in ENERGY STAR for SSL Luminaires version 1.0 and updated in version 1.1, DOE intends to require LM-79 and LM-80 test results from laboratories accredited for these procedures by the National Voluntary Laboratory Accreditation Program (NVLAP). DOE suspended this requirement for the first year of the ENERGY STAR SSL program through September 30, 2009. DOE hereby extends this requirement to Sept 30, 2010. Below is a brief characterization of the status of the test procedures, NVLAP accreditation process, and laboratory progress, which inform the decision to extend these deadlines.

A. LM-80-08 was published by IESNA in September 2008. Several factors limit the availability of LM-80 testing services and the timeline for NVLAP accreditation. First, due to the long-term nature of lumen maintenance testing, it is almost exclusively conducted in-house by LED manufacturers. Second, significant changes were made to the final LM-80 test procedure compared to earlier drafts, effectively eliminating any “first mover advantage” towards accreditation. Third, strict temperature control methods required by LM-80 necessitate specialized thermal chambers and auxiliary equipment. Cost and space requirements for this equipment, along with the minimum 6,000 hour test period make LM-80 testing by independent test labs impractical at this time.

B. LM-79 and LM-80 were added to the NVLAP Energy Efficient Lighting Products program and NIST began accepting applications for accreditation to these procedures in March 2009. The time required for the accreditation process varies depending on lab capabilities, existing accreditations, and other factors. NIST estimates that the first LM-79 and LM-80 accredited laboratories will complete the process by the end of 2009. Both independent and manufacturer-owned laboratories are eligible to earn LM-79 and LM-80 accreditation.

X. In situ Temperature Measurement Test

DOE will accept ISTMT results from laboratories approved by OSHA as Nationally Recognized Testing Laboratories (NRTLs). Alternatively, DOE will accept ISTMT results from independent laboratories qualified under the DOE CALiPER testing program as listed at http://www1.eere.energy.gov/buildings/ssl/test_labs.html under the heading “CALiPER Testing Laboratories, Laboratories Qualified, Verified, and Contracted for 2009 CALiPER LM-79 Testing and LM-79 Testing for ENERGY STAR for SSL”. Alternatively, ISTMT may be carried out by laboratories recognized through UL’s Data Acceptance Program.

XI. Lumen Maintenance – LM-80 thresholds

DOE established a pass/fail threshold for lumen maintenance compliance, based on the available 6,000 hour data provided by the LM-80 test report. The requirements differ for applications requiring 25,000 hours of useful life and those requiring 35,000 hours, as follows:

Application required minimum useful life (L_{70})	Required lumen maintenance at 6,000 hours
25,000 hours	91.8%
35,000 hours	94.1%

These percentages result from solving an exponential decay function for 25,000 and 35,000 hours, respectively, to determine the minimum lumen maintenance necessary to achieve those thresholds.

In some cases, manufacturers continue to collect LM-80 data beyond 6000 hours (LM-80 establishes 6000 hours as a minimum test period, but recommends 10,000 hours). If additional data is available, it may be used to meet the lumen maintenance requirements, with the following thresholds:

Required lumen maintenance at test periods exceeding 6000 hours		
Cumulative hours of testing	For 25000 hour projected L_{70} life	For 35000 hour projected L_{70} life
7000	90.5%	93.1%
8000	89.2%	92.2%
9000	88.0%	91.2%
10000	86.7%	90.3%
11000	85.5%	89.4%
12000	84.3%	88.5%
13000	83.1%	87.6%
14000	81.9%	86.7%
15000	80.7%	85.8%

Scope

This document is an accompaniment to DOE's ENERGY STAR® for SSL Luminaires Criteria and provides manufacturers with information about product submission, testing laboratories and requirements, and using "product groups" to reduce testing costs.

Pre-qualification Activities

A manufacturer should take several steps before submitting products for ENERGY STAR qualification.

A. Become an ENERGY STAR Partner

All manufacturers who wish to earn the ENERGY STAR label for their products must first become an ENERGY STAR SSL Partner. ENERGY STAR Partnership Agreements are available for download at www.energystar.gov/sslpartners or by submitting an e-mail request to ssl@energystar.gov. If your company is already an ENERGY STAR partner under a different product category, you still need to fill out a new form.

B. Find a DOE-Approved or NVLAP Accredited Laboratory

ENERGY STAR requires independent product testing to verify performance against the key requirements laid out in the criteria. DOE maintains a list of approved independent testing laboratories to perform the required testing, as outlined below and in **Table 2**. Laboratories can now begin the process for NVLAP accreditation for both IESNA LM-79-2008 and IESNA LM-80-2008. NVLAP accreditation involves a rigorous process demonstrating technical competence, quality control, proficiency testing, and laboratory impartiality and objectivity. As of September 30, 2010, DOE will only accept LM-79 and LM-80 test results from NVLAP-accredited labs.

Photometric Testing

Independent testing laboratories qualified, verified, and recognized through DOE's CALiPER program shall be used for photometric testing under the ENERGY STAR program. Labs must satisfactorily complete round-robin testing verification adhering to IESNA LM-79-08 test procedures for integrating sphere and/or goniophotometric testing of SSL luminaires and lamps. Alternatively, labs must successfully acquire NVLAP accreditation for LM-79 testing or be currently accredited under the NVLAP Program for Energy Efficient Lighting (EEL) Products while in the process of attaining NVLAP LM-79 accreditation. A list of currently qualified test labs is below. Manufacturers are encouraged to check for updates to this list available at: http://www1.eere.energy.gov/buildings/ssl/test_labs.html

Integrating Sphere (LM-79 Section 9.1 and 9.2)

- Independent Testing Laboratories, Inc. – Boulder, CO
- Intertek - Cortland, NY
- Luminaire Testing Laboratory, Inc. – Allentown, PA
- Lighting Sciences, Inc. – Scottsdale, AZ
- OnSpeX/CSA International – Atlanta, GA

- Aurora International Testing Laboratory – Aurora, OH
- GE Consumer & Industrial – Lighting Product Testing Laboratory – Cleveland, OH

Goniophotometry (LM-79 Section 9.3)

- Independent Testing Laboratories, Inc. – Boulder, CO
- Intertek - Cortland, NY
- Luminaire Testing Laboratory, Inc. – Allentown, PA
- Lighting Sciences, Inc. – Scottsdale, AZ
- OnSpeX/CSA International – Atlanta, GA
- GE Consumer & Industrial – Lighting Product Testing Laboratory – Cleveland, OH

In situ Temperature Measurement Test (ANSI/UL 1598-04 or ANSI/UL 153-05)

ISTMT must be conducted with the luminaire installed in its appropriate application, as defined in UL 1598 (for hard-wired luminaires) or UL 153 (for corded products). ISTMT may be carried out concurrently with UL safety testing.

Product safety testing of electrical equipment is required under OSHA Safety Standards (29 CFR Part 1910). In particular, SSL luminaires submitted for ENERGY STAR qualification must be tested and certified to ANSI/UL 1598-04 or ANSI/UL 153-05 standards. OSHA has approved a number of organizations as Nationally Recognized Testing Laboratories (NRTLs), and can accept products that have been properly certified by these laboratories.

DOE will accept ISTMT results from the following NRTLs, recognized as qualified by OSHA:

- Canadian Standards Association (CSA) (also known as CSA International)
- Communication Certification Laboratory, Inc. (CCL)
- Curtis-Straus LLC (CSL)
- FM Approvals LLC (FM)(formerly Factory Mutual Research Corporation)
- Intertek Testing Services NA, Inc. (ITSNA) (formerly ETL)
- MET Laboratories, Inc. (MET)
- NSF International (NSF)
- National Technical Systems, Inc. (NTS)
- SGS U.S. Testing Company, Inc. (SGSUS) (formerly UST-CA)
- Southwest Research Institute (SWRI)
- TUV America, Inc. (TUVAM)
- TUV Product Services GmbH (TUVPSG)
- TUV Rheinland of North America, Inc. (TUV)
- Underwriters Laboratories Inc. (UL)
- Wyle Laboratories, Inc. (WL)

A current listing of NRTLs and detailed qualifications and contact information is provided on OSHA's NRTL Program webpage (<http://www.osha.gov/dts/otpca/nrtl/>).

Alternatively, ISTMT may be carried out concurrently with photometric (LM-79) testing. DOE will accept ISTMT results from independent laboratories qualified under the DOE CALiPER testing program as listed at http://www1.eere.energy.gov/buildings/ssl/test_labs.html under the heading “CALiPER Testing Laboratories, Laboratories Qualified, Verified, and Contracted for 2009 CALiPER LM-79 Testing and LM-79 Testing for ENERGY STAR for SSL”.

Alternatively, ISTMT may be carried out by laboratories recognized through UL’s Data Acceptance Program.

C. Submit Products to Labs for Testing

Manufacturers are responsible for product testing costs. Each product must adhere to the appropriate standards and test procedures. To help ease the burden of testing, DOE will allow manufacturers to qualify one product as a representative sample of similar models.

D. Creating Product Groups

DOE will allow manufacturers to qualify multiple products of a similar nature using one model. For example, the same basic fixture may be available with various shade, reflector, finish, or trim options. Manufacturers will define the product group and identify the specific model used for testing to represent the entire group. When choosing this test sample, DOE advises applicants to choose the variation which will have the most difficulty meeting the ENERGY STAR criteria. This will ensure that other group members will perform at least as well as the tested product.

Table 1 summarizes allowable variations under the product grouping allowance.

Table 1 - Variations within Product Groupings

Housing/Chassis	allowed, with conditions [†]
Heat Sink/Heat Management	not allowed
Finish	allowed
Reflector/Trim	allowed
Shade/Diffuser	allowed
Mounting	allowed
Light Source	allowed, w/ conditions
Power Supply	allowed, w/ conditions
[†] The light source, heat sink, and power supply are integrated into housing/chassis variations in such a way that the thermal performance of the luminaire is not significantly degraded by the housing/chassis.	

As seen in the table, housing/chassis variations and heat sink/heat management component variations within a group are not allowed because they may materially impact LED performance (a possible exception for chassis/housing variations is allowed as noted). Finish, reflector/trim, shade/diffuser, and mounting variations are allowed.

Light source and power supply variations are allowed with certain conditions:

Substitute LED packages that produce the identical quality and quantity of light

Products qualified under a single application may include LED package(s)/module(s)/array(s) and power supplies from more than one manufacturer, but the LED package(s)/module(s)/array(s) and power supplies must be substitutable components used to manufacture essentially identical luminaires and must be intended to produce the same quantity and quality of light. All LED package(s)/module(s)/array(s) substitution components must separately comply with the Option 1 (Component Performance) requirements in the Lumen Maintenance section.

Same luminaire available in different CCTs

If a manufacturer offers the same luminaire with different correlated color temperatures (CCTs), ENERGY STAR will allow those products to be grouped together, so long as the LED package(s)/module(s)/array(s), drive current, electronics, and thermal management are otherwise identical. At a minimum, manufacturer must submit one set of LM-80, In-situ Temperature Measurement Test (ISTMT), and LM-79 test results applicable to the product version with the lowest CCT.

Manufacturers are allowed to retroactively add new products to a grouping.

More information on Product Grouping can be found in **Attachment A**.

Submittal Process

On-line Product Submission Tool

To submit your test results for ENERGY STAR approval, DOE has created an on-line product submission tool for partners. Partners must submit their information via the on-line tool posted at www.energystar.gov/sslpartners. The process is as follows:

Step 1. Set up your “My ENERGY STAR® Account” (MESA).

Once you register as an ENERGY STAR SSL Partner, you will receive an e-mail that contains your MESA set-up information. This information will include a user name and password required for accessing the on-line product submittal tool.

Step 2. Launch the On-line Product Submittal Tool.

A link to the On-line Product Data Submittal Tool will be added to your ENERGY STAR SSL Partner landing page. Launching the tool will begin the data submittal process, and take you to the tool’s main screen which displays the manufacturer’s information (i.e., name, address, contacts, etc.).

Step 3. Enter Product Information.

The On-line Product Submittal Tool provides entry fields for all information needed for ENERGY STAR qualification. Next to each data entry field is guidance on its required minimum level of detail. You can upload LM-79 test reports directly to the tool and receive instant feedback on how the photometric results compare with specific ENERGY STAR product category requirements. The tool also allows you to upload other test reports and packaging proofs for review by ENERGY STAR.

At any time during the submittal process, you can save your work for completion at a later date. A progress meter indicates your stage of completion in the data submittal/qualification process.

Step 4. Submit Application

Once you have completed the appropriate data entry fields, click “Submit.”

Once a product has been submitted by a manufacturer, ENERGY STAR will review the results and notify the applicant within one calendar week of acceptance, rejection, or the need for additional information. If you experience problems with the On-line Product Submission Tool, please contact ssl@drintl.com.

Testing

Temperature Measurement Point (TMP)

LED package, array, or module manufacturers and power supply/driver manufacturers designate specific locations on their products which act as surrogate points for measuring junction temperature (t_j) or, in the case of power supplies, the point to which the warranted temperature is measured. DOE generically designates these locations as the temperature measurement points (TMPs) for the purposes of measurement in testing.

TMP for the LED (TMP_{LED})

Knowledge of the thermal pathway between the LED die junction and a designated external measurement point on the package, array, or module allows manufacturers to accurately estimate junction temperature. The surrogate temperatures and their measurement locations vary from manufacturer to manufacturer. Some manufacturers use temperatures measured at the solder joint (t_s) at the board attachment site; some use the package case temperature (t_c); and others use the board temperature (t_b) on the module. Collectively, these locations serve the same function, i.e., to correlate an external temperature to the junction temperature, which is critical for determining LED lumen maintenance. For purposes of this document, the measurement locations for t_s , t_c , and t_b are Temperature Measurement Points for LEDs (TMP_{LED}).

TMP for the Power Supply (TMP_{PS})

The longevity of power supplies is highly dependent upon operating temperature and thermal environment. It is standard practice in the lighting industry to tie the product warranty to maintained operating temperature—referred to as the case temperature (t_c)—for which most manufacturers designate a measurement location on the power supply case. For purposes of this document, the measurement locations for t_c (or other manufacturer designated location) are Temperature Measurement Points for power supplies (TMP_{PS}).

Required Test Reporting and Tolerance

Manufacturers are required to test their products at approved testing laboratories, and provide the results to DOE as part of the submittal process. Table 2 defines the required testing and reporting, sample size, and applicable tolerance for the ENERGY STAR criteria. Table 3 presents the zonal lumen tolerances for the individual Category A applications.

Table 2 - Required Test Reporting and Tolerance¹

Performance Characteristic	Methods of Measurement/ Reference	Approved Test Facility	Required Documentation	Sample Size	Tolerance
Luminaire Efficacy	IESNA LM-79-08 Section 9.1, 9.2 or 9.3 ANSI C82.2	DOE CALiPER Recognized or NVLAP Accredited	IESNA LM-63-03 Formatted Photometric Report (required for electronic submission) and/or Goniophotometer Test Report and/or Integrating Sphere Output Report	One	-3%
Minimum Light Output	IESNA LM-79-08 Section 9.1, 9.2 or 9.3	DOE CALiPER Recognized or NVLAP Accredited	IESNA LM-63-03 Formatted Photometric Report (required for electronic submission) and/or Goniophotometer Test Report and/or Integrating Sphere Output Report	One	- 10%
Zonal Lumen Density	IESNA LM-79-08 Section 9.3	DOE CALiPER Recognized or NVLAP Accredited	IESNA LM-63-03 Formatted Photometric Report (required for electronic submission) and/or Goniophotometer Test Report	One	See Table 3
Lumen Maintenance (L₇₀)	OPTION 1: Component Performance				
	IESNA LM-80-08	NVLAP Accredited or LED Package, Module, or Array Manufacturer (must begin process of NVLAP accreditation)	LED package, module, or array manufacturer test report (data table and chart) showing relative light output over time. For L ₇₀ of 25,000 hours, average of sample at 6,000 hours shall have lumen maintenance of ≥ 91.8%. For L ₇₀ of 35,000 hours, average of sample at 6,000 hours shall have lumen maintenance of ≥ 94.1%. <i>(continued on next page)</i>	For LED packages, the average of at least 25 samples for each temperature measured For LED modules and arrays, the average of at least 10 samples for each temperature	0%

¹ After September 30, 2010, DOE will only accept LM-79 and LM-80 test results from NVLAP-accredited laboratories.

	In Situ Temperature Measurement Test (ISTMT) ANSI/UL 1598-04, ANSI/UL 153-05	OSHA approved NRTLs or DOE CALiPER Recognized or UL Data Acceptance Program labs	1. Test report indicating the Temperature Measurement Point for the hottest LED (TMP _{LED}) in the luminaire. 2. Diagram/picture of the TMP _{LED} location with an arrow indicating the thermocouple attachment point.	One	N/A
	OPTION 2: Luminaire Performance				
	IESNA LM-79-08 Section 9.1, 9.2 or 9.3	DOE CALiPER Recognized or NVLAP Accredited	IESNA LM-63-03 Formatted Photometric Report and/or Goniophotometer Test Report and/or Integrating Sphere Output Report 1. Report @ T = 0 hours 2. Report @ T = 6000 hours	One	N/A
Color Rendering Index	IESNA LM-79-08 Section 9.1 CIE 13.3-1995 IESNA LM-58	DOE CALiPER Recognized or NVLAP Accredited	Integrating Sphere Output Report	One	- 2 points of required CRI
Correlated Color Temperature	IESNA LM-79-08 Section 9.1 ANSI C78.377-08	DOE CALiPER Recognized or NVLAP Accredited	Integrating Sphere Output Report	One	ANSI C78.377 Defined
Color Spatial Uniformity	IESNA LM-79-08 CIE 15: 2004 IESNA LM-58 IESNA LM-16	DOE CALiPER Recognized or NVLAP Accredited	Self Certification Note: A laboratory test report must be submitted upon DOE request.	One	N/A
Color Maintenance	IESNA LM-80-08 CIE 15: 2004 IESNA LM-58 IESNA LM-16	NVLAP Accredited or LED Package, Module, or Array Manufacturer	Self Certification Note: A laboratory test report must be submitted upon DOE request.	One	N/A
Power Factor	ANSI C82.77	OSHA approved NRTLs or DOE CALiPER Recognized or UL Data Acceptance Program labs	Laboratory test report	One	- 3%

Power Supply TMP_{PS}	ISTMT ANSI/UL 1598-04, ANSI/UL 153-05	NRTLs or DOE CALiPER Recognized or UL Data Acceptance Program labs	<ol style="list-style-type: none"> 1. Test report indicating the Temperature Measurement Point for the power supply (TMP_{PS}) in the luminaire. 2. Diagram/picture of in the TMP_{PS} location with an arrow indicating the thermocouple attachment point. 	One	N/A
Output Operating Frequency	Oscilloscope Manual	Any	Self Certification. Output operating frequency is measured by attaching an oscilloscope between the driver and the LED package. It is conducted simultaneously with the measurement of the output drive.	One	N/A
Noise	Not to exceed 24 dB when measured 12" in any direction. Class A sound rating for power supplies installed within the fixture are not to exceed a measured level of 24 dBA (audible).	Any	<p>Self Certification. Sound is measured using a sound meter (similar in performance to B&K type 2209) where the microphone is located 12 inches from the fixture in any direction.</p> <p>Note: A laboratory test report must be submitted upon DOE request.</p>	One	N/A
Electromagnetic and Radio Frequency Interference	Residential applications must meet FCC 47 CFR Part 15 (remote) or 18 (integral) Consumer Emission Limits. Commercial ones must meet FCC 47 CFR Part 15 (remote) or 18 (integral) Non-consumer Emission Limits.	Any	<p>Self-Certification</p> <p>Note: A laboratory test report must be submitted upon DOE request.</p>	One	N/A
Transient Protection	Comply with IEEE C.62.41-1991, Class A operation. Seven strikes of a 100 kHz ring wave, 2.5 kV level, for both common and differential mode.	Any	<p>Self-Certification</p> <p>Note: A laboratory test report must be submitted upon DOE request.</p>	One	N/A

Minimum Operation Temperature (Outdoor)	≥-20°C	Any	Self-Certification Note: A laboratory test report must be submitted upon DOE request.	One	N/A
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Table 3 - Zonal Lumen Tolerances

Category A Application	Zonal Lumen Density Requirement			Tolerance (Values below are subtracted from minimum % values on the left)	Method of Measurement
	Zone (bilaterally symmetrical)	Minimum Percentage of Total Lumens	Maximum Percentage of Total Lumens		
Under-cabinet kitchen lighting	0-60°	60%	--	- 5%	IESNA LM-79-08 Section 9.1
	60-90°	25%	--	- 10%	
Under-cabinet shelf-mounted task lighting	0-60°	60%	--	- 5%	
	60-90°	25%	--	- 10%	
Under-cabinet shelf-mounted task lighting (asymmetrical distribution)	60-90°	12.5%		- 3%	
Portable desk task lights	0-60°	85%	--	- 15%	
Recessed, surface, and pendant-mounted downlights	0-60°	75%	--	- 10%	
Cove lighting	120 - 150°	35%	--	- 3%	
Surface-mounted luminaires with directional heads	0 - 90°	85%	--	- 3%	
Wall wash luminaires	20 - 40°	50%	--	- 3%	
Outdoor wall-mounted porch lights	0-90°	85%	--	- 5%	
Outdoor step lights	0-90°	85%	--	- 10%	
Outdoor pathway lights	0-90°	85%	--	- 10%	
Outdoor pole/arm-mounted decorative luminaires	0-90°	85%	--	- 3%	
	110° and above	--	0%	+ 3%	
Bollards	90 – 110%	--	0 – 15%	+ 3%	
	110° and above	--	0%	+ 3%	

Lumen Maintenance Testing

The ENERGY STAR program offers two compliance methods for lumen maintenance testing: 1) Component Performance and 2) Luminaire Performance. Given the potential delays in market introduction required for full luminaire testing, DOE anticipates the majority of products submitted will be qualified via component performance testing.

OPTION 1: Component Performance

The Component Performance option allows the applicant to demonstrate compliance with the lumen maintenance requirement by demonstrating the highest temperature LED package(s), array(s), or module(s) used in the luminaire operates at or below temperatures yielding an L_{70} of 25,000 or 35,000 hours, respectively.

IESNA LM-80-2008

The *IESNA LM-80-2008 Approved Method for Measuring Lumen Maintenance of LED Light Sources* prescribes the measurement of lumen maintenance for LED-based packages, arrays, and modules only and does not entail testing of the entire luminaire. LED packages, arrays or modules are tested for at least 6,000 hours at a minimum of three discrete case temperatures: 55°C, 85°C and a third temperature at the discretion of the manufacturer $\pm 2^\circ\text{C}$. At a minimum, light output is measured every 1,000 hours and recorded for a minimum of 6,000 hours.

In Situ Temperature Measurement Test (ISTMT)

IESNA LM-80 defines lumen maintenance testing for LED packages, arrays, and modules. Because LEDs are incorporated into luminaires with heat sinks, optical elements, power supplies, etc. and then operated in a variety of ambient environments, LM-80 by itself is not a predictor of luminaire lumen maintenance. To relate the results of the LM-80 test to the luminaire, DOE requires verification of LED and power supply temperatures in environments that simulate real-world applications (in situ) with tests that measure the temperature of both the highest temperature LED in the luminaire and the power supply at steady-state thermal equilibrium. The procedure is called the *In-situ Temperature Measurement Test (ISTMT)* which follows *ANSI/UL 1598-2004 Luminaires* or *ANSI/UL 153-2005 Portable Luminaires*. It includes the addition of two (or more) thermocouples, one for the LED package, array, or module and one for the power supply.

According to UL, hard-wired luminaires are separated into two broad categories: 1) Surface—products that are surface-mounted, suspended or freestanding where the fixture housing is exposed to free air and 2) Recessed—products recessed into ceilings or walls and often placed in direct contact with insulation. ANSI/UL1598 prescribes enclosures for luminaires for the purposes of simulating in situ operation and conducting temperature measurements for electrical safety (see Figure 2). In efforts to facilitate testing and minimize costs, DOE has reduced the number of environments to the fewest possible without significantly affecting the resulting steady-state temperatures. **Table 4** lists the appropriate section references in ANSI/UL 1598.

Portable luminaires shall follow the procedures contained within ANSI/UL 153.

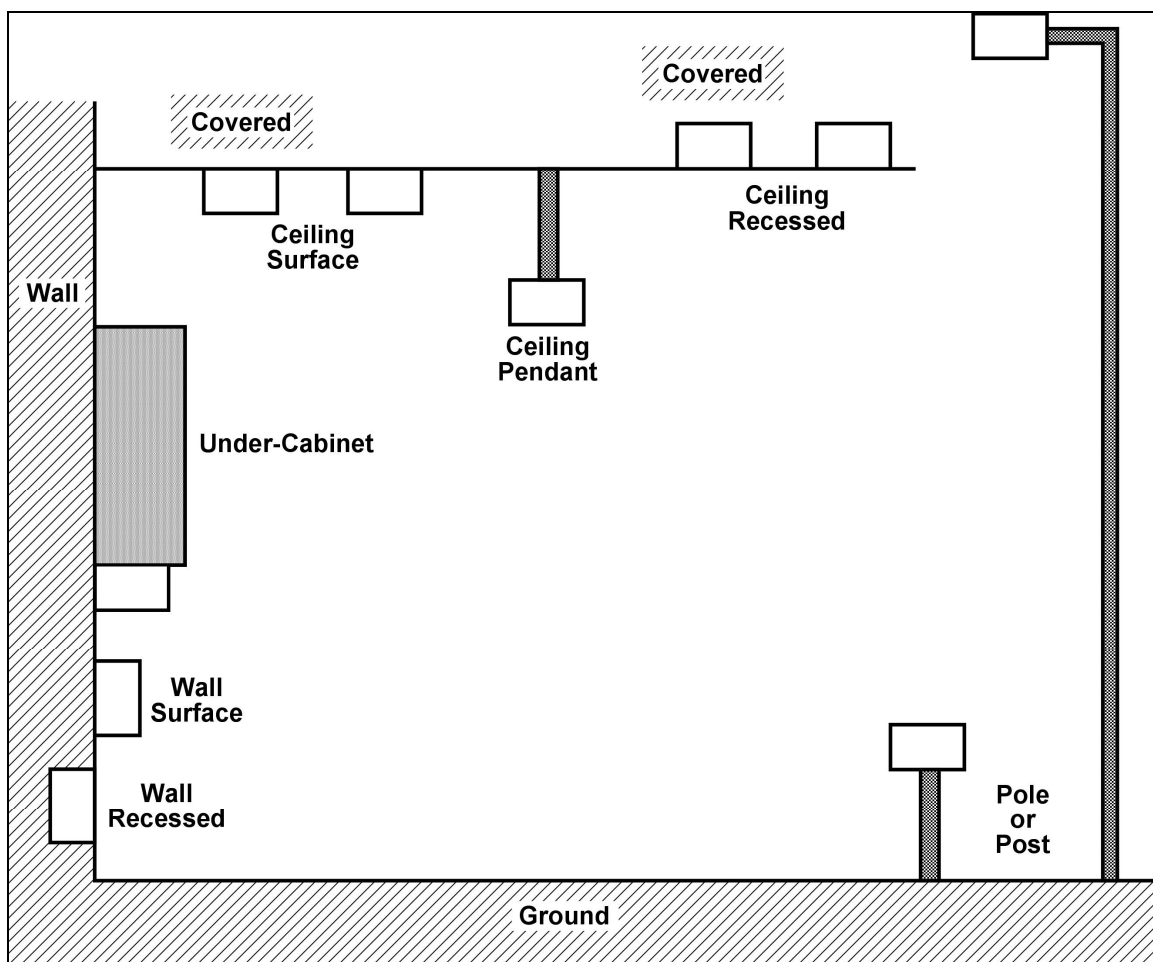


Figure 2 - ANSI/UL 1598 Test Environments

Table 4 – In Situ Test Environments

Luminaire Types	Mounting Orientation	
	Horizontal	Vertical
Surface		
Surface	Section 19.10	Section 19.11
Surface-mounted under-cabinet	Section 19.12	
Suspended	No apparatus required except if in situ mounting is $\leq 4"$ from the surface. In this case mount to apparatus defined in Section 19.10	
Freestanding	No apparatus required	
Recessed		
Non-IC	Section 19.13	Section 19.13 except without insulation
IC	Section 19.15	Section 19.15

Conditions for Use

To be eligible for the component performance option, **ALL** conditions below must be met. If

ANY of the conditions are not met, the component performance option may not be used and the applicant must use the luminaire performance option for compliance.

1. The LED package, array, or module used in the fixture has been tested according to LM-80.
2. The LED package, array, or module manufacturer prescribes/indicates a TMP on the package, array, or module.
3. The LED package, array, or module TMP is accessible to allow temporary attachment of a thermocouple for measurement of in situ operating temperature. Access via a temporary hole in the housing (no larger than 0.375" diameter), tightly resealed during testing with putty or other flexible sealant, is allowable. The size and location of the access port shall be documented in the submittal for the purposes of repeatability.
4. The LED package, array, or module must contain all optics and electronics which significantly change the color and/or intensity of the light emitted from the luminaire. Luminaires incorporating remote phosphors, secondary phosphors, optics, and/or color or intensity correction electronics that are not contained within the LED package, array, or module must be tested under OPTION 2.

Test Procedure

The ISTMT follows all requirements of ANSI/UL 1598/153 with the following additions:

1. One or more additional thermocouples are attached to the highest temperature LED package or module in the luminaire (i.e., TMP_{LED}).
2. One or more additional thermocouples are attached to the power supply/driver at the TMP_{PS}. For off-the-shelf remote power supplies manufacturers typically provide a measurement location (case temperature designated by a “dot” adjacent to a (t_c) symbol) for warranty purposes. In situations where the TMP_{PS} is not designated by the manufacturer, or where power supplies are integrated with the LED package(s), array or module(s), fixture manufacturers should identify the TMP_{PS} to be used for warranty purposes.

Guidance for Thermocouple Attachment

- Manufacturers shall select and designate the highest temperature LED package, array, or module in the luminaire. In most cases the individual LED in the middle of symmetric arrays should be hottest. A well designed thermal management solution will minimize the temperature gradient across packages.
 - For square/rectangular/circular arrays the individual LED closest to the center
 - For other configurations it is recommended manufacturers sample several LEDs to find the highest temperature device within the luminaire.
- Temperature probes shall be in contact with the TMP and permanently adhered. Permanent adhesion consists of high temperature solder, conductive adhesives (e.g. accelerator/UV activated or epoxy), or melting the tip into plastic or other approved product recommended by the temperature probe manufacturer. Tape alone is not acceptable for providing good thermal contact at the thermocouple/TMP interface.
- The thermocouple tolerance shall conform to ASTM E230 **Table 1** “Special Limits” ($\leq 1.1^{\circ}\text{C}$ or 0.4%, whichever is greater).

TMP Evaluation

DOE has established a pass/fail threshold for lumen maintenance compliance, based on the available 6,000 hour data provided by the LM-80 test report. The requirements differ for applications requiring 25,000 hours of useful life and those requiring 35,000 hours, as follows:

Table 5. Required lumen maintenance at 6000 hours

Application required minimum useful life (L₇₀)	Required lumen maintenance at 6,000 hours
25,000 hours	91.8%
35,000 hours	94.1%

These percentages result from solving an exponential decay function for 25,000 and 35,000 hours, respectively, to determine the minimum lumen maintenance necessary to achieve those thresholds.

In some cases, manufacturers continue to collect LM-80 data beyond 6000 hours (LM-80 establishes 6000 hours as a minimum test period, but recommends 10,000 hours). If additional data is available, it may be used to meet the lumen maintenance requirements, with the following thresholds:

Table 6. Required lumen maintenance at test periods exceeding 6000 hours

Cumulative hours of testing	For 25000 hour projected L₇₀ life	For 35000 hour projected L₇₀ life
7000	90.5%	93.1%
8000	89.2%	92.2%
9000	88.0%	91.2%
10000	86.7%	90.3%
11000	85.5%	89.4%
12000	84.3%	88.5%
13000	83.1%	87.6%
14000	81.9%	86.7%
15000	80.7%	85.8%

Note: The final version of LM-80 was published September 2008 with several significant changes relative to prior drafts, including how the case temperature is maintained (via ambient temperature versus current modulation) and in the three LED case temperatures at which the packages are maintained 55°C, 85°C, and one other temperature selected by the manufacturer (compared to the earlier drafts that required 45°C, 65°C and 85°C).

DOE recognizes that all LED manufacturers may not have 6,000 hours worth of data for all three case temperatures prescribed in LM-80. DOE therefore will allow prior data collected to be used for compliance purposes until March 31, 2010, after which date new product submissions will be required to include full LM-80 test results.

This next section describes how DOE will evaluate LM-80 data. There are three possible scenarios for determining the lumen maintenance for the product submitted to ENERGY STAR:

SCENARIO 1

The in situ measured TMP_{LED} is greater than the highest case temperature collected according to LM-80 procedures. In this case the product cannot qualify under Option 1 as there is no test data to substantiate manufacturer claims. Products that fall under this scenario must be successfully tested according to Option 2 in order to qualify.

SCENARIO 2

The in situ measured TMP_{LED} is less than the lowest case temperature (T_c) or solder-joint (T_s) temperature at which LM-80 data was collected. In this case the product must use the data from the lowest case temperature measured according to LM-80 procedures.

SCENARIO 3

The in situ measured TMP_{LED} is bounded above and below by case temperature data collected according to LM-80 procedures. In this case linear interpolation shall be used to determine the lumen maintenance for the proposed product, as follows:

$$L_{TMP} = L_{below} + \left(\frac{L_{above} - L_{below}}{T_{s, above} - T_{s, below}} \right) (TMP_{LED} - T_{s, below})$$

Where:

L_{below} = Lumen maintenance (%) below the TMP_{LED} @ 6000 hours

L_{above} = Lumen maintenance (%) above the TMP_{LED} @ 6000 hours

$T_{s, below}$ = LM-80 case temperature (°C) below the TMP_{LED}

$T_{s, above}$ = LM-80 case temperature (°C) above the TMP_{LED}

TMP_{LED} = In situ measured TMP of the hottest LED within the luminaire

L_{TMP} = Calculated lumen maintenance of the hottest in situ LED within the luminaire

EXAMPLE:

In situ measured TMP (TMP_{LED}) = 67°C

LED Manufacturer LM-80 test data for XYZ Package

	Case Temperature		
Time (hours)	25°C	55°C	85°C
0	100%	100%	100%
⋮	⋮	⋮	⋮
6000	99%	95%	90%

Applying the equation above:

$$L_{TMP} = 95 + \left(\frac{90 - 95}{85 - 55} \right) (67 - 55)$$

$$\therefore L_{TMP} = 93.0\%$$

Component Performance “Passing” Threshold

The luminaire **PASSES** the Component Performance Lumen Maintenance requirements if the following three conditions are met:

1. The LM-80 test report for the package, array, or module demonstrates lumen maintenance of $\geq 91.8\%$ for a projected L_{70} of 25,000 hours (indoor residential) or $\geq 94.1\%$ for a projected L_{70} of 35,000 hours (outdoor residential and all commercial)².
2. The ISTMT temperature at the TMP is less than the lowest temperature that correlates to a lumen maintenance $\geq 91.8\%$ (residential) or $\geq 94.1\%$ (commercial) in the LM-80 test. Or the in-situ temperature at the TMP, when input into the linear interpolation equation, results in a lumen maintenance $\geq 91.8\%$ for residential products or $\geq 94.1\%$ for outdoor residential and commercial products.
3. The drive current measured in the fixture is less than or equal to the drive current specified in the LM-80 test report.

Submittal requirement

Applicant submits the following information to ENERGY STAR:

1. LM-80 test report (data table and chart) showing relative light output over time at various case (T_c), board (T_b), or solder-joint (T_s) temperatures and at a drive current greater than or equal to the measured current of the LED package, array, or module used in the luminaire. A template will be released shortly and will be available at www.energystar.gov/sslpartners.
2. In situ temperature measurement test report with the measured temperature of the hottest LED (TMP_{LED}).
3. Diagram/picture of the TMP_{LED} location with an arrow indicating the thermocouple attachment point.

NOTE: If more than one type of LED is used in a luminaire, an LM-80 test report and the above described ISTMT and interpolation procedures must be applied to each type of LED used in the luminaire. If LM-80 test reports do not exist for the different packages used in the luminaire, the product must undergo Option 2 to verify lumen maintenance.

Successor or next generation LED packages. LED package manufacturers continue to improve their products, incorporating various upgrades into revised and next-generation packages. Typically these are incremental improvements, rather than entirely new products. To avoid

² Note that 91.8% and 94.1% are the passing thresholds for 6000 hour LM-80 data. For longer test periods, please see thresholds listed in Table 6 above.

significant delays in qualifying luminaires using LED packages that are successors of LED packages previously approved for lumen maintenance in DOE's ENERGY STAR SSL program, DOE allows for provisional ENERGY STAR approval based on the following conditions:

1) Luminaire manufacturer must submit at least 3000 hours of lumen maintenance (based on LM-80) data for the successor LED package(s) used, at the appropriate temperature and drive current for the luminaire, and assuming all other required provisions for ENERGY STAR qualification are met by the luminaire.

2) At least 6000 hours of lumen maintenance data for the successor LED package(s) must be provided to the DOE ENERGY STAR SSL program as soon as available.

3) If complete lumen maintenance data is not provided within 6 months of the provisional approval date, all qualified luminaires using the successor packages will face de-listing.

OPTION 2: Luminaire Performance

The Luminaire Performance option allows the applicant to show compliance with the lumen maintenance requirement by demonstrating that the light output from the luminaire at 6,000 yields $\geq 91.8\%$ lumen maintenance for a projected L_{70} of 25,000 hours (indoor residential) or $\geq 94.1\%$ lumen maintenance for a projected L_{70} of 35,000 hours (outdoor residential and all commercial).

Luminaire Performance “Passing” Threshold

The luminaire **PASSES** the Lumen Maintenance requirements if:

1. Based on the LM-79 test report, light output determined at 6000 hours divided by the light output at 0 hours multiplied by 100 yields $\geq 91.8\%$ lumen maintenance for a projected L_{70} of 25,000 hours (indoor residential) or $\geq 94.1\%$ lumen maintenance for a projected L_{70} of 35,000 hours (outdoor residential and all commercial).
2. The luminaire must be operated continuously in the appropriate UL 1598/153 environment except when it is removed to perform the LM-79 light output tests.

Submittal requirement

Applicant submits the following information to ENERGY STAR:

1. LM-79 test report at 0 hours
2. LM-79 test report at 6000 hours after continuous operation in the appropriate UL1598/153 environment

Power Supply Qualification

Power supplies integrated with the LED package(s), array(s) or module(s), or enclosed within the fixture shall be tested in situ under steady-state operating conditions, with power supply case temperature measured at the designated TMP_{PS} . The luminaire passes power supply requirements if the measured temperature at the TMP_{PS} is less than or equal to the warranted temperature specified by the power supply manufacturer.

Power Supply “Passing” Threshold

The power supply **PASSES** if:

1. The power supply measured in situ at the TMP_{PS} is less than the power supply

manufacturer's three year minimum warranted temperature.

Submittal requirement

Applicant submits the following information to ENERGY STAR:

1. ANSI/UL1598/153 Test Report with the measured temperature from the TMP_{PS} .
2. Diagram/picture of the TMP_{PS} location (if not permanently marked on the circuit board or power supply case) with an arrow indicating the thermocouple attachment point.
3. Warranty from the driver manufacturer indicating the maximum power supply case temperature for which a minimum three year warranty is offered.

Attachment A

Product Groups

Luminaires are often available in multiple variations and options. For example, the same basic fixture may be available with different shades, diffusers, trim, reflectors, mountings, and/or sizes. To avoid the need to test all product variations in the ENERGY STAR SSL program, DOE allows for qualification of product groups. Allowable variations within a qualified group may be a function of:

- Component substitution: where components of a single version of a luminaire may be substituted in the manufacturing process based on component availability, cost, etc., while not substantively affecting product performance.
- Product variations: where multiple versions of a luminaire are based on the same LED platform (i.e., LED module(s)/array(s) and driver), deliver similar function and performance, but vary in physical appearance.

ENERGY STAR partners may self-define product groups consisting of a collection of products sharing similar features, and submit a single luminaire from the group for testing. DOE will verify the applicant's grouping rationale and—if the submitted product passes testing—will extend the ENERGY STAR qualification to the entire product group. Continued group qualification will be contingent on successful follow-up testing under DOE's Quality Assurance (QA) program, as described in the ENERGY STAR Program Requirements for SSL Luminaires (ver. 1.1).

LED Platform

All luminaires in a product group must share the same type of LED platform. The LED platform consists of an LED package, array, or module with integrated thermal management (e.g., heat sinking), and a power supply (driver), assembled and operated to produce a specified quantity and quality of light. Substitution of platform components is allowed, provided that it does not significantly alter light output or color properties.

Substitute power supplies must provide the same input power as that used in the tested product, and may not exceed the drive current specified in LM-80 testing for the associated LED package(s)/module(s)/array(s). Substitution of LED package, array or modules is allowed, subject to the light quantity and quality restrictions described above. Further, the package, array, or module must be tested according to LM-80 and demonstrate the required lumen maintenance (L_{70}) characteristics.

Consistent LED platform performance is critical to group qualification, as any luminaire in the group is subject to follow-up QA testing and must demonstrate compliance with the current ENERGY STAR criteria in effect at the time of testing.

Component Substitution

Multiple luminaires qualified under a single application may incorporate LED packages, arrays, or modules and power supplies from more than one manufacturer, but the substituted components and resulting LED platform must produce the same quantity and quality of light as the LED platform used in the qualifying luminaire. Further, all LED package, array, or module substitution components must comply separately with ENERGY STAR lumen maintenance qualification requirements.

Additional Requirements

For manufacturers seeking to qualify product groups on the basis of tests on a single product, DOE requires partners to submit for qualification the luminaire likely to be the lowest-performing (relative to ENERGY STAR requirements) luminaire within a group. Selecting the lowest performing luminaire within a group is the responsibility of the manufacturer. Successful qualification of the lowest-performing version will help ensure that other luminaires in the group will meet or exceed ENERGY STAR requirements, pass any subsequent QA testing, and maintain qualification status for the product grouping. Manufacturers are allowed to retroactively add models to a product group; to start the process they must inform their D&R account manager. Product groups may not span more than one of the lighting applications contained in Category A, e.g., individual porch lights and walkway lights may not be combined into a single product group.

Applicants are reminded that thermal management is a key element of LED luminaire performance and that heat must be removed from the package, array, or module —by conduction or convection—to maintain required light output, efficacy, and color quality. For this reason, DOE will not allow significant variations in luminaire housings and chassis within product groupings that are likely to affect thermal performance because material and design changes can alter the LED thermal pathway and diminish lighting performance.

However, product variations including those to housing and chassis that do not significantly degrade thermal performance are allowed. For example, outdoor wall-mounted porch lights within a product group could include a coach lantern with metal mullions or an opaque glass cylinder with a top shade while sharing the same LED platform and internal mounting hardware. Similarly, outdoor pathway lights with the same LED platform and similar basic structure may be offered in a range of ornamental shapes and embellishments.

Limited variations of luminaire housings within product groups are allowed for ENERGY STAR qualification. Applicants self-define their product groups, and should explain their rationale for each product group proposed, including selection of the version submitted for testing. DOE will evaluate grouping rationales on a case-by-case basis and, where appropriate, advise the applicant of any recommended modifications to the product group. Note that applicants ultimately bear the risk of inappropriate product grouping, which could result in failed follow-up QA testing, non-compliance, and revocation of product grouping eligibility.

As the ENERGY STAR eligibility criteria document details, applicants may also include

variations in luminaire finish, reflectors/trim, shades/diffusers, and mountings within product groups. In all cases, however, DOE encourages applicants to be conservative in their selection of grouped luminaires, and adhere to the following basic requirements and guidelines:

- 1) It is mandatory to use the same type of LED platform for all luminaires in a product grouping;
- 2) To help ensure product group qualification, submit the lowest-performing compliant luminaire in the group for testing;
- 3) Limit product variations in a group to ensure all members meet the ENERGY STAR requirements.